THE RATE OF FEEDING OF THE COMMON OYSTER DRILL, UROSALPINX CINEREA (SAY), AT CONTROLLED WATER TEMPERATURES

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Information on the voracity of the oyster drill, *Urosalpinx cinerea* (Say), within certain ranges of water temperature has been reported by a number of investigators, but evaluation of their destructiveness at specific temperatures maintained within close limits is virtually non-existent. In addition, the conclusions regarding the destructiveness of drills within the different temperature ranges are drawn from observations made at widely separated geographical areas (Carriker, 1955).

Observations by Stauber (1950) and Loosanoff and Davis (1950–51) on certain activities of drills from different areas of the North Atlantic Coast suggest the existence of distinct physiological races. If such races exist, a temperature-dependent activity, such as feeding, determined for drills from one area would not necessarily be applicable to drills of another habitat. Therefore, we have attempted to establish the feeding rate of a single geographical population of oyster drills at several constant temperatures. It was felt that such a study would not only provide more detailed information about the predation of drills, but also present a basis of comparison for investigators interested in the problem of physiological races.

Methods

A bank of wooden frames, constructed to hold a number of enamel trays (18″ × 20″ × 3″), was arranged on a laboratory water table. Each tray was supplied with a separate, continuous flow of sea water. Temperatures were adjusted by mixing cold and heated sea water in glass cylinders, just above the frames, giving each bank of trays a separate supply of water at a constant temperature (Loosanoff, 1949). Water in the trays was maintained at approximately ± 1.0° C. of the temperature desired.

Since the drills had a tendency to move up the sides of the tray and leave the water, covers were made to fit into each tray to keep the drills below the water line. They were constructed of Lucite plastic frames with a covering of ⅛″-mesh Saran plastic screening.

The salinity of the water deviated only slightly from 25‰ throughout the experiments and is, therefore, considered to have exerted no influence on differential feeding at the various temperatures.

To obtain a more comprehensive evaluation of feeding by drills at different temperatures, two species of bivalves, the common oyster, *Crassostrea virginica* Gmelin, and the mussel, *Mytilus edulis* Linné, were used as foods in separate experiments.

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Each tray contained 20 adult, Long Island Sound drills measuring from 20.0 to 25.0 mm. in height, and either 30 to 40 oyster spat, ranging in size from 10.0 to 30.0 mm., or 40 mussels, ranging in size from 20.0 to 30.0 mm. Spat were growing on cultch (old oyster shells) in such numbers that four to five shells supplied the total needed. The oyster spat clusters or mussels were so distributed about the tray that no large concentration of food occurred at any one point. The drills were dispersed throughout the tray to decrease the opportunity for feeding by two or more drills on the same bivalve. At no time during the experiments did the drills consume all of the bivalves available in any tray, thereby indicating that feeding was maximal for each feeding period.

The drills were brought to the experimental temperatures by keeping them for two to three hours at each five-degree level until the desired temperature was reached. After the experiment was begun the number of bored bivalves, as well as the number and condition of drills present, was ascertained at regular intervals. Following each such examination, oyster spat or mussels were added to replace those destroyed by the drills. Mortality of drills was low at all temperatures, except 30.0° C. All dead drills were replaced by drills from stocks kept at the same water temperature as the experimental groups to assure that their prior conditioning was the same.

Results

The feeding rates are expressed as the number of bivalves destroyed per drill during one week of feeding. Since low temperatures could not be maintained during the spring and summer, observations on the groups at 5.0° C. were discontinued after 52 days, on the 10.0° C. groups, at 69 days, and on the 15.0° C. groups, at 90 days; while the groups at 20.0°, 25.0° and 30.0° C. were under observation for 102 days (Table I).

At 5.0° C. the drills did not feed, nor did they show any tendency to attack the spat during the 52 days of the experiment. They usually remained in groups, each

Table I

Feeding rate of U. cinerea on oyster spat, size range 10–30 mm., at controlled water temperatures

Temperature ° C.	5.0		10.0		15.0		20.0		25.0		30.0	
Tray	1	2	1	2	1	2	1	2	1	2	1	2
No. of drills	20	20	20	20	20	20	20	20	20	20	20	20
Feeding period (days)	52	52	69	69	90	90	102	102	102	102	102	102
No. of spat consumed	0	0	49	41	124	133	313	355	429	398	285	327
Spat consumed per drill per week	0	0	0.25	0.21	0.48	0.52	1.07	1.21	1.47	1.37	0.98	1.12

drill with the foot extended and attached firmly to the tray. Movement of a few inches by some drills, as shown by mucus paths, was noted on several occasions.

Feeding at 10.0° C. appeared to be limited to occasional attacks by individual drills since the rate of feeding was only about one spat per drill every four to five weeks. The rate of feeding on oyster spat increased as the temperature increased from 10.0° to 25.0° C. The rate approximately doubled for each five-degree increase in water temperature from 10.0° to 20.0° C. However, the next five-degree rise, to 25.0° C., increased the rate of feeding only about 25 per cent over that at 20.0° C., and a distinct decrease in the rate of feeding occurred at 30.0° C. Thus, the optimum temperature for feeding of drills on oyster spat was at or near 25.0° C.

The drills maintained at 30.0° C. were also slower in turning over and attaching to the tray than those kept at 25.0° C. On two occasions, when the temperature rose to about 34.0° C., 70 to 80 per cent of the drills were killed, although in neither

Table II

Feeding rate of U. cinerea on mussels, size range 20–30 mm., at controlled water temperatures

Temperature ° C.	10.0		15.0		20.0		25.0		30.0	
Tray	1	2	1	2	1	2	1	2	1	2
No. of drills	20	20	20	20	20	20	20	20	20	20
Feeding period (days)	34	34	57	57	57	57	44	44	44	44
No. of mussels consumed	1	4	39	32	88	73	101	109	89	105
Mussels consumed per drill per week	0.01	0.04	0.24	0.20	0.54	0.45	0.80	0.87	0.71	0.82

instance were they exposed to this temperature for more than 16 hours. The surviving drills were not attached to the tray or to the oyster spat, as they usually were at 30.0° C. These observations suggest that while drills do feed at 30.0° C., this approaches the lethal temperature level.

Comparable data for oyster drills feeding on mussels show that the optimum feeding temperature again lies near 25.0° C. (Table II). Apparently, only a few of all the drills kept at 10.0° C. fed during the 34 days of the experiment. The rate of feeding at 15.0° C. approximated one mussel per drill every five weeks. This rate was about doubled for each five-degree rise in temperature from 15.0° to 25.0° C. Although the rate of feeding at 30.0° C. was lower than that at 25.0° C., it was not as low as would be expected from the results when oyster spat were used as food. Probably, the rate of drill feeding at 30.0° C., in the mussel-fed experiment, was somewhat higher due to differences in handling. It was necessary to examine each tray and change the mussels daily to avoid a high mortality and resultant bacterial decomposition of mussels at 30.0° C. Thus, the drills may have been induced to attack more mussels because they were unable to feed without interruption.

Statistical treatment of the data by analysis of variance indicates that differences in feeding rate between temperature levels are highly significant ($F = 85.96$ with $df = 4,5$ for mussels as food and $F = 143.84$ with $df = 5,6$ for oyster spat as food; both values being significant beyond the 0.001 level). In order to determine which of the differences between temperatures were significant, a test for significance of gaps between means was applied (Bliss and Calhoun, 1954). Results of this test

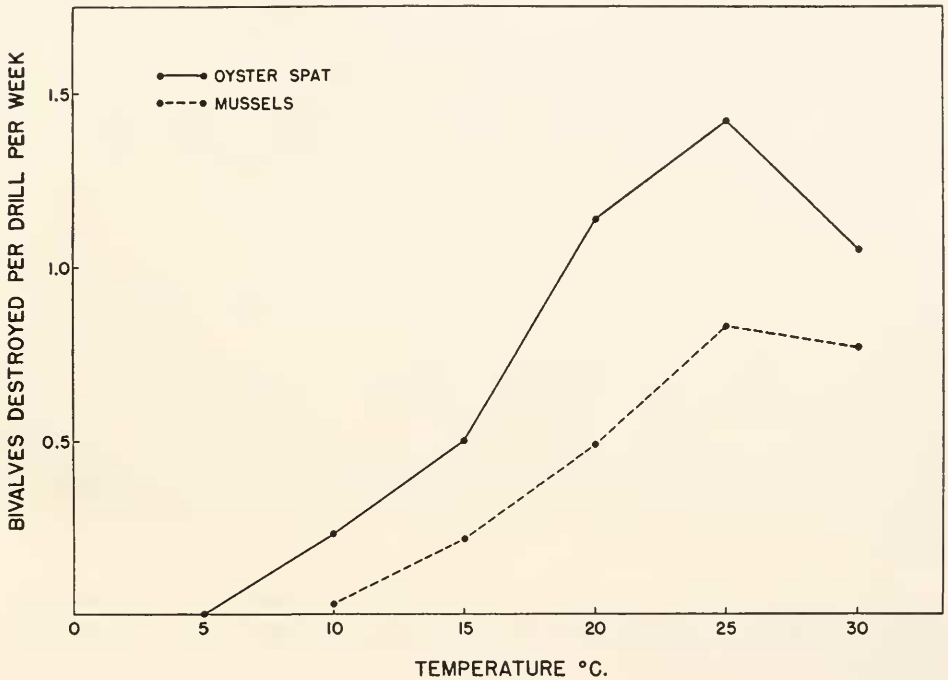

FIGURE 1. Feeding rates of *U. cinerea* at constant temperatures on young oysters or mussels. (Points are based on combined data of replicates at each temperature level.)

indicated a minimum difference between means of 0.162 for oyster spat as food. Thus, all gaps between means are significant except between 20.0° and 30.0° C. (Fig. 1). With mussels as the food organism, the minimum difference was 0.136. Thus, all gaps between means are significant except between 25.0° and 30.0° C.

Discussion

The rate at which the drills destroyed oyster spat was higher than the rate at which they destroyed mussels at each of the temperatures used in these experiments (Fig. 1). This may indicate a preference of the drills for oyster spat, rather than mussels, as food. However, it is more probable that much of this difference was due to the spatial arrangement of the mussels in the tray, which necessitated more movement by the drills between feedings than when oyster spat, growing in clusters, was used for food. In addition the slightly larger average size of the mussels gave the drills somewhat more food per mussel killed than per oyster spat.

This comparison of feeding by drills on two species of bivalves shows a marked increase in destruction for each five-degree rise in water temperature within the range from 10.0° to 25.0° C. With either food, the peak of feeding occurred at 25.0° C. Since this temperature is seldom reached over the oyster beds in Long Island Sound, it is doubtful that drills in our waters are often feeding at their maximum rate.

As the drills did not feed at 5.0° C. and their rate of feeding on oyster spat was lowest at 10.0° C., a similar experiment was run at 7.5° C. to determine whether this temperature was above or below the threshold at which feeding on spat could occur. As with drills at 10.0° C., feeding at 7.5° C. was sporadic. In one experiment when 20 drills were used, one spat was killed after 27 days and two more during the next 37 days. Another group of 20 drills destroyed two to three spat per week during the first two weeks, did not feed for the next two weeks and, again, killed two to three spat per week for the final four weeks of the experiment.

The minimum temperature for feeding of drills has been reported as 9.5° C. (Galtsoff *et al.*, 1937), 9.0° C. (Loosanoff and Davis, 1950–51), 8.0° C. (Engle, 1953), and 6.5° C. by Andrews and McHugh (Carriker, 1955). The last figure was an average over a period in which the maximum temperature reached 9.5° C. and, therefore, cannot be regarded as the actual temperature at which feeding occurred. The lower temperature limit for feeding of 7.5° C. established in this study is in general agreement with these figures. However, it is apparent that short-term observations will not suffice to determine the lower temperature limit for feeding. Drills went as long as 27 days at 7.5° C. before any feeding occurred, and thus, it is possible that drills will feed at even lower temperatures, if kept for many months. In this study no feeding on oyster spat was observed at 5.0° C. during 52 days of exposure.

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Summary

1. Feeding by drills, *Urosalpinx cinerea* (Say), of Long Island Sound did not occur at 5.0° C.

2. The lower temperature limit for feeding was about 7.5° C., although feeding at this temperature was intermittent.

3. The feeding rate increased steadily as the water temperature was raised from 10.0° to 25.0° C., and decreased as the temperature was increased from 25.0° to 30.0° C.

4. The optimum temperature for feeding, when either *Crassostrea virginica* (Gmelin) or *Mytilus edulis* Linné was used as food, was 25.0° C.

5. The upper temperature limit for feeding was about 30.0° C.

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